Biological Evaluation of the

Scenic Area and Red Pine Stands at Hearts Content

Allegheny National Forest, Pennsylvania

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TABLE OF CONTENTS

1. PROJECT LOCATION/DESCRIPTION…….. 3

2. PROJECT OBJECTIVES…….. 3

3. PROJECT METHODS ……. 3

4. PROJECT RESULTS (Existing conditions)
   HEARTS CONTENT SCENIC AREA……... 4
   RED PINE PLANTATIONS…….. 5

5. DISCUSSION
   HEARTS CONTENT SCENIC AREA…… 7
   RED PINE PLANTATIONS……... 7

6. MANAGEMENT ALTERNATIVES
   HEARTS CONTENT SCENIC AREA…… 8
   RED PINE PLANTATIONS……... 10

7. RECOMMENDATIONS
   HEARTS CONTENT SCENIC AREA…… 10
   RED PINE PLANTATIONS……... 11

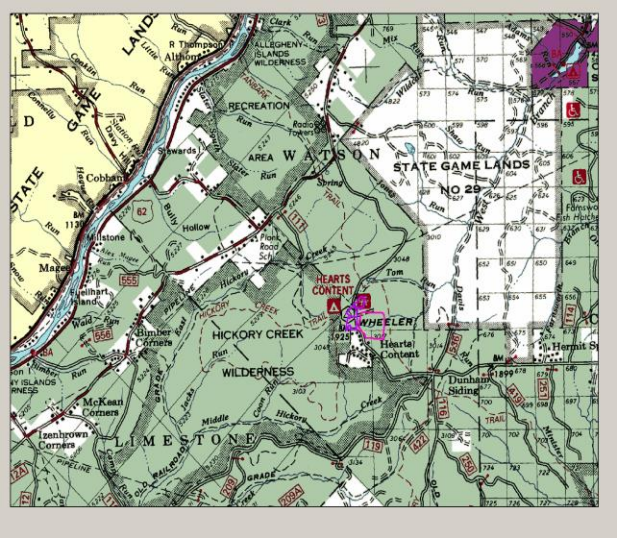
8. ADDITIONAL INFORMATION
   HEMLOCK WOOLLY ADELGID…….. 12
   IMIDACLOPRID…….. 13
   HAZARD TREES……. 14

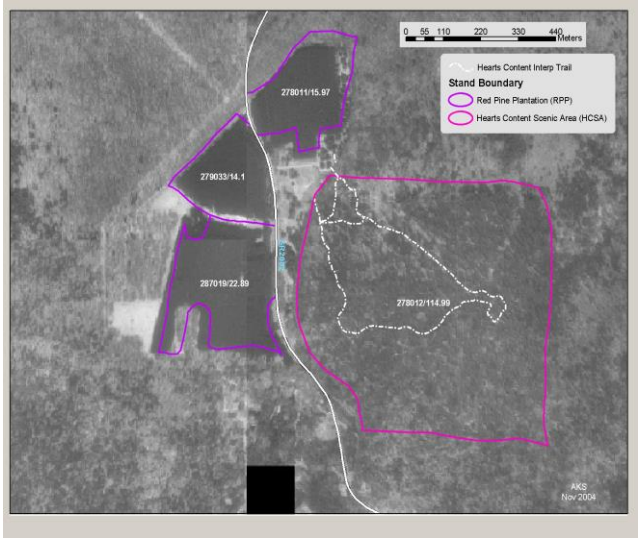
9. LITERATURE CITED…….…… 15

PROJECT LOCATION/DESCRIPTION

The Hearts Content Scenic Area (HCSA) is located 15 miles southwest of Warren, Pennsylvania, on State Route 2002 (figures 1 and 2). The area was designated a scenic area in 1969 and added to the National Register of Natural Landmarks in 1973 (USDA 1986). It features some of the oldest and largest hemlock trees in the Eastern United States (USDA 1986). The HCSA encompasses about 115 acres and consists of mature hemlock, white pine, and mixed hardwoods. Two interpretive trails run through this area—the short loop trail is 0.25 miles long and the long loop trail is 1.1 miles in length. Adjacent to the HCSA are three 46-year-old red pine plantations (RPPs), planted on a 6- by 6-foot spacing, through which the 1.3-mile Wheeler Loop Trail runs. A 1- to 2-acre area of one of the stands was thinned while the remainding 58 acres were untouched.

Figures 1 and 2. ***Hearts Content Recreation Area, Scenic Area and red pine plantations, Bradford Ranger District, Allegheny National Forest.***





PROJECT OBJECTIVES

The objectives of this biological evaluation were to 1) assess if the hemlock woolly adelgid (HWA), *Adelges tsugae* Annand (Homoptera: Adelgidae), had reached the HCSA, 2) develop treatment alternatives and recommendations to reduce and/or control the hemlock woolly adelgid when it arrives, 3) assess current insect and disease activities within the RPPs, 4) develop treatment alternatives and recommendations for the RPPs to reduce and/or control current and future insect and disease activity, and 5) assess the hazard trees along the interpretive trail of the HCSA.

PROJECT METHODS

The guidelines used to evaluate current insect and disease population density and impacts include[1]: 1) stand condition, 2) visual estimates of stand-level insect and disease densities, 3) visual estimates of individual tree insect and disease densities, i.e., insect emergence holes, pitch tubes, woodpecker activity, etc., and 4) visual estimates of tree condition.

[1] Because of restrictions on destructive sampling, Forest Health Protection staff used signs and symptoms to tentatively identify insect and disease agents active in these stands.

Hearts Content Scenic Area

One hundred hemlock trees were randomly sampled within the 115-acre HCSA (comp. 278, stand 12) for the presence of hemlock woolly adelgid. The stand was divided into four sections and 25 hemlock trees were randomly sampled within each section based on a predetermined direction and distance (for information on the sampling method and design, please see FHP publication NA-04-20).

On a walking tour of the trails in the project area to assess hazard trees, the NA Hazard Tree guidelines (Albers et al. 1996 and Pokorny 2003) were applied at the sites of all monuments, plaques, and interpretive signs. The guidelines were interpreted in light of the results of beech bark disease (BBD) surveys of the ANF (please see FHP publication Beech Bark Disease -Hearts Content Scenic Area, October 19 1987).

Red Pine Plantations

Thirteen 30- by 30-foot plots were established within the three pine stands (comp. 279, 279, and 278; stands 19, 33, and 11). Eleven plots were located in the unthinned areas and two were located within the thinned area. Diameter at breast height (DBH), live crown ratio (LCR), and crown area were recorded for each tree located within each plot. An additional 15 trees located on the external edge of the stands were also measured (these trees were free to grow on one side since being planted).

Insect and disease surveys were conducted in all three RPPs. In addition to these surveys, all dead and fading trees within stand 11 were classified using a five–class condition class system (table 1) and their location was recorded using a Garmin GPS unit. Fading is a condition in which the tree is in the process of dying and the needles are changing from green to red.

Table 1. ***Dead and dying red pine condition class based on retention of needles and branches, Hearts Content Recreation Area, Bradford Ranger District, Allegheny National Forest.***

Code	Needles	Branches	Time Since Death*
Fading	Present, changing from green to red	Fine branches present	--
Dead with needles	Present, dry	Fine branches present	1-2 years
Fine branches	Absent	Fine branches present	1-5 years
No fine branches	Absent	No fine branches	>5 years
No branches	Absent	No branches	>5 years

* Derived from Forest Inventory and Analysis guidelines (USDA 2001)

PROJECT RESULTS

Hearts Content Scenic Area

No hemlock woolly adelgid was found within the HCSA. A significant number of hazard trees resulting mainly from BBD were observed adjacent to most plaques, monuments, and interpretive signs.

Red Pine Plantations

Based on the 13 plots, the unthinned areas of the three stands averaged 366 trees per acre and 144 square feet of basal area per acre while the thinned area averaged 150 trees per acre and 110 square feet of basal area (tables 2 and 3). An additional 89 trees per acre and 20 square feet of basal area per acre of mortality existed in the unthinned area, while mortality in the thinned portion accounted for an additional 75 trees per acre and 28.5 square feet of basal area per acre.

The range and average LCR, DBH, and crown area for the unthinned, thinned, and external portions of the stands are presented in table 4. On average, the unthinned plots had the smallest LCR, DBH, and crown area while the thinned area had a larger average LCR, DBH, and crown area. The external trees had the largest average LCR, DBH, and crown area. Trees in the thinned area have responded well to this silvicultural treatment as evidenced by a larger average LCR (31 percent vs. 24 percent), DBH (11.5″ vs. 8.3″), and crown area (119 square feet vs. 46 square feet) than the unthinned areas. The understory in the thinned area and openings created by dead trees in the unthinned area were comprised mainly of fern (figure 4).

Table 2. ***Basal area (BA) and trees per acre (TPA) in the red pine stands (Stands 11, 19, and 33), Hearts Content Recreation Area, Bradford Ranger District, Allegheny National Forest, October 7-8, 2004. (All plots were located in unthinned areas.)***

Plot #	Stand #	TPA Live	TPA Dead	BA Live	BA Dead
1	19	376	0	165	0
2	19	639	75	213	8
3	19	226	188	106	30
4	19	413	113	160	18
7	19	188	113	104	41
8	33	188	75	83	28
9	33	601	75	194	12
10	33	263	188	95	34
11	11	376	75	139	20
12	11	376	0	160	0
13	11	376	75	165	30
	Range	188-639	0-188	83-213	0-41
	Average	366	89	144	20

Table 3. ***Basal area (BA) and trees per acre (TPA) in the thinned portion of Stand 19, Hearts Content Recreation Area, Bradford Ranger District, Allegheny National Forest, October 7-8, 2004.***

Plot #	TPA Live	TPA Dead	BA Live	BA Dead
5	150	75	106	30
6	150	75	114	27
Average	150	75	110	28.5

Table 4. ***Comparison of LCR, DBH, and crown area of thinned, unthinned, and external portions of Stands 11, 19, and 33, Hearts Content Recreation Area, Bradford Ranger District, Allegheny National Forest, October 7-8, 2004.***

	Unthinned	Thinned	External[#]
LCR Range	5-35%	25-40%	50-100%
LCR Average	24%	31%	79%
DBH Range	4.8-12.2″	8.8-13.3″	8.8-14.8″
DBH Average	8.3″	11.5″	12.1″
Crown Area Range	3-198 sq. ft.	50-211 sq. ft.	38-242 sq. ft.
Crown Area Average	46 sq. ft.	119 sq. ft.	122 sq. ft.

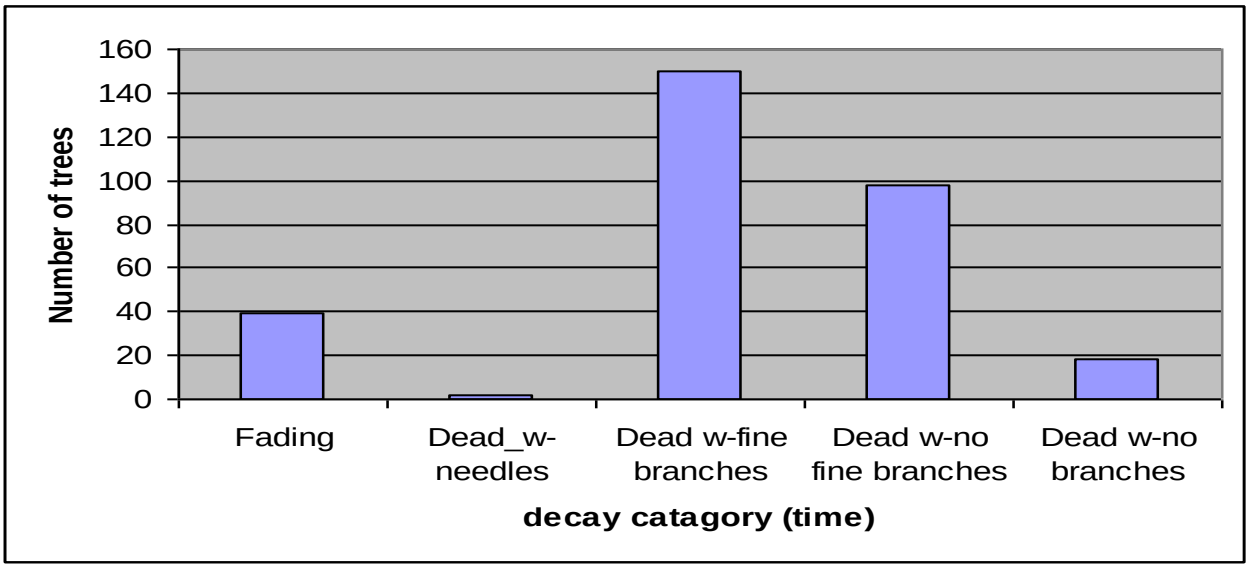
[#]External = a tree located on the edge of a stand that has been free of competing trees on one side since it was planted.

The higher percentage of dead trees in the thinned stand (table 3) is more than likely an artifact of the type of thinning performed. The row thinning done in Stand 19 removed both desirable trees and undesirable trees (small DBH, small crown, and low vigor). It is likely that the smaller trees that had been suppressed were stressed as a result of the thinning and died.

Past and current insect and disease activity was detected in all of the RPPs. *Ips* bark beetles (Coleoptera: Scolytidae) and red turpentine beetles (*Dendroctonus valens* LeConte) (Coleoptera: Scolytidae) were found to be currently active in all stands. Stand 11 is an excellent example of the sequence of mortality occurring in the RPPs (figure 3). Thirty-nine intermediate and codominant trees are currently fading as a result of insect attack[1] and/or competition (figure 5). Location mapping of dead and dying trees showed no recognizable pattern of mortality, i.e. pockets.

While an occasional fading BBD-impacted beech tree was observed, the initial wave of beech mortality has swept over the area, leaving behind significant numbers of dead beech (i.e., hazard) trees in close proximity to plaques, monuments, and interpretive signs.

Figure 3. ***Number of dead and dying trees in each decay category in Stand 11, Hearts Content Recreation Area, Bradford Ranger District, Allegheny National Forest, October 7-8, 2004.***



Figures 4 and 5. ***Fern growing in the understory openings created by dead pines (left) and a codominant red pine fading due to insect attack (right) at the Hearts Content Recreation Area, Bradford Ranger District, Allegheny National Forest, October 7-8, 2004.***

DISCUSSION

Hearts Content Scenic Area

Even though HWA has not yet been found within the HCSA, we have included management alternatives for this insect. It is vitally important that field-going personnel continue to monitor for evidence of HWA in this area.

Monuments, plaques, and interpretive signs

"A hazard tree exists when there is a defective tree and a target within range." This is the working definition used by the NA Hazard Tree team. A fuller definition, taken from Albers et al. (1996) is:

> "A hazard tree is a tree with structural defects likely to cause failure of all or part of the tree, which could strike a 'target.' A 'target' can be a vehicle, building, or a place where people gather, such as a park bench, picnic table, street, or back yard."

In the context of targets, the NA Hazard Tree team has accepted that any structure that causes the public to congregate at a point in a forest or recreational site creates a target. **Thus, manmade monuments, plaques, or interpretive signs create a target.** Even if an area is being managed overall as a "natural area," the erection of a plaque, monument, or interpretive sign takes the structure and the area around it out of the classification as a "natural area." The hazard area for each target is a 360-degree area with a radius equal to the height of the surrounding hazard trees.

Red Pine Plantations

Many factors play a role in the successful colonization of a tree by bark beetles. Of these, *susceptibility* is one of the most important. Susceptibility is a term used to describe the degree to which a tree can resist attack by bark beetles (Cates and Alexander 1982). Any factor that affects the primary defensive system of a host will increase susceptibility. For example, the following factors have been associated with increased susceptibility to bark beetle attack: tree senescence, flooding, drought, pollution, and competition, among others (Coulson and Witter 1984). Vigorously growing trees, by contrast, are not as susceptible to attack as are physiologically weakened trees. From the standpoint of beetle population dynamics, the beetle must overcome tree resistance mechanisms in order to colonize the host (Berryman 1972). Failure to do so results in mortality of the beetle and survival of the host (Coulson and Witter 1984). The type and lack of thinning in the RPPs have resulted in a situation in which trees have become susceptible to attack by bark beetles. Although the insect species that are currently active in these stands normally would not be considered as aggressive or tree killers, large populations can build up when natural events, such as drought or windstorms, create large amounts of susceptible trees. The current condition of the RPPs (high basal area, low live crown ratio) has maintained insect populations and lead to tree death, which will continue in the future.

Using the mortality and decay data collected from Stand 11, it appears that mortality has been ongoing for a number of years with a peak sometime within the last 5 years (figure 3). It is likely that this trend of increasing and decreasing mortality will continue as bark beetle populations fluctuate with the susceptibility of individual trees. It is expected that this trend will continue in the RPPs unless some corrective action is taken.

Although the pouch fungus (*Cryptoporus volatus* (*Pk.*) *Shear*) was observed several times on the boles of dead pines, a more important observation was the absence of any evidence of pathogenic attack by *Armillaria*. The pouch fungus is a common conifer sapwood-rotting fungus most frequently associated with bark beetle-killed pines. In a survey of red pine pocket decline-impacted stands on the ANF, pathogenic *Armillaria* attack was never recorded. The best explanation for the absence of *Armillaria* in the pine stands is to assume that either the species of *Armillaria* or the strains of these species found on the ANF are hardwood adapted and have a low level of pathogenicity towards pines.

MANAGEMENT ALTERNATIVES

Hearts Content Scenic Area

Although no hemlock woolly adelgid (HWA) was found in the HCSA, four management options have been evaluated for the hemlock trees in the HCSA when HWA does arrive. The intervention options were evaluated based upon the following objectives: 1) protecting hemlock timber and resource values, and 2) reducing hemlock woolly adelgid populations in infested areas. In addition, a fifth alternative on hazard trees is discussed below.

Alternative 1: No Action

This alternative is considered the environmental baseline (the no action alternative). As a result, HWA populations would be allowed to increase and decrease naturally, without intervention. Because HWA has a high reproductive capacity and has demonstrated the ability to rapidly spread in recent years, it is expected that HWA populations would continue to increase throughout the HCSA and accelerate their spread to currently noninfested trees and stands within this area. Population densities will likely fluctuate periodically depending on the severity of winters, but rebound following such events, and consequently, impacts to hemlock resources throughout the HCSA would likely increase as more hemlocks succumb to this insect.

Because of the significant number of hazard trees observed along the interpretive trails, the no action option will increase the likelihood of injury occurring to visitors in those areas adjacent to targets.

Alternative 2: Release Predator Beetles to Establish Long-Term Population Control (Recommended Action)

This alternative involves the release of laboratory reared predator beetles *Sasajiscymnus tsugae, Laricobius nigrinus, Scymnus sinuanodulus*, and *Scymnus ningshanensis* in hemlock woolly adelgid-infested hemlock trees to accelerate the establishment of these predator beetles. The proposed releases would depend on the availability of beetles. Monitoring and evaluation efforts will continue for 3 years after release to document the establishment and dispersal of the beetle and evaluate its effectiveness in reducing HWA population densities and protecting hemlock health on a stand-level basis. USDA Forest Service Forest Health Protection (FHP) entomologists will be providing a work plan with protocols to be followed for the 3-year project. USDA Forest Service FHP personnel will be responsible for conducting the releases, monitoring beetle dispersal and changes in HWA population densities, conducting tree health assessments, and reporting their results.

Alternative 3: Systemic Insecticides (Recommended Action)

This alternative involves the use of trunk- and soil-injected systemic insecticides to reduce hemlock woolly adelgid populations on moderately to highly infested trees. Monitoring and evaluation efforts will continue for 3 years after treatment to document the effectiveness of treatment in reducing HWA population densities and protecting hemlock health on an individual-tree basis. USDA Forest Service Forest Health Protection entomologists will be providing a work plan with protocols to be followed for the 3-year project. Additional treatments within this site are possible in the future based on monitoring results.

Several types of systemic insecticides can be injected (e.g., imidacloprid, bidrin, or Metasystox-R®) or implanted (e.g., acephate) into hemlock trees, and another (Merit®) can be applied as a soil drench or injected into the soil around hemlock trees. These insecticides are absorbed and transported by the vascular system of the tree to feeding adelgids and will effectively suppress HWA populations (McClure 1992a, Steward and Horner 1994, Evans 2000, Doccola et al. 2003, Webb et al. 2003). Of the trunk- and soil-injection systemic insecticides available, only imidacloprid marketed under the trade names Merit®, Pointer®, Imi-jet®, or Imicide® is currently labeled for soil and tree injection for the control of adelgids in forest trees.

Alternative 4: Other HWA Control Alternatives Considered, but Dismissed

4.1 Ground spraying with horticultural oils, insecticidal soaps, and foliar insecticides

These methods of treatment can be effective in situations where there is access to the trees for ground spraying equipment, including pumping trucks with high-pressure hoses, and the entire crown of each tree can be saturated with the spray (Evans 2000). Although this type of access is available for part of the HCSA, concerns for drift caused this alternative to be dismissed.

4.2 Aerial spraying

Aerial spraying with horticultural oils or insecticidal soaps is not an effective treatment because it fails to provide the needed "saturation" coverage of each tree crown. Aerial spraying with more toxic insecticides (e.g., malathion or diazinon) would have very significant, unacceptable impacts on a wide range of nontarget insects and other animals (Evans 2000). Therefore, this alternative was considered infeasible and was dismissed.

4.3 Pheromone traps or other methods of disrupting reproduction

Because HWA reproduces asexually (its populations are entirely parthenogenetic; females reproduce without males), it is not possible to disrupt reproduction through pheromone traps or other, similar methods (Evans 2000). Therefore, this alternative was considered infeasible and was dismissed.

Alternative 5: Hazard Tree Mitigation (for the areas around plaques, monuments, and interpretive signs) **(Recommended Action)**

This alternative involves the felling or topping of all hazard trees within one tree height of plaques, monuments, and interpretive signs. Dead trees with no signs of root rot can be retained as wildlife trees near the structures provided they have their height reduced to the point where they cannot reach the public or structures when they eventually fail. The attached publications are provided as examples of ways in which Alternative 5 can be implemented.

RECOMMENDATIONS

It is recommended that the Allegheny National Forest decide in favor of **Alternatives 2** and **3** (release and establishment of predator beetles and soil and trunk injections of the systemic insecticide imidacloprid) in the HCSA when hemlock woolly adelgid (HWA) arrives. Host acceptance tests and choice tests have demonstrated that predator beetles will feed on nontarget adelgid species and the possibility exists that these other adelgid and aphid species may be fed on. Imidacloprid is a systemic and contact insecticide exhibiting low to moderate mammalian toxicity, with primary activity on sucking insects. With each of these treatment options comes the potential for nontarget effects; land managers must balance the risk of these effects with the potential benefits that come with the control of the HWA. Introduction of predator beetles is expected to reduce the impact of HWA and may provide lasting and effective control in a cost-efficient manner. Soil and trunk injections of imidacloprid are expected to reduce HWA populations on moderately to heavily infested trees and provide 1 to 2 years of protection.

For the areas around structures (on trails) that would induce the public to congregate, it is recommended that the Allegheny National Forest decide in favor of **Alternative 5**. Implementation of hazard tree mitigation would involve felling all hazard trees within one tree height of the structures so that none can fall upon the structure or any member of the public.

Red Pine Plantations

Five management options have been evaluated for the RPPs. The intervention options were evaluated based upon the following objectives: 1) protecting red pine timber and resource values, and 2) reducing insect and disease in infested areas. Each option is discussed below.

Chemical control of bark beetles is not recommended for these areas because: 1) trees need to be monitored regularly so that attacks can be detected and the pesticide applied, 2) no insecticide currently available kills larvae tunneling under the bark (infested trees), 3) to be effective, treatments must target the adults by spraying the bark so that they are killed when they land on the tree and attempt to bore into the bark (Anon. 2004), and 4) these treatments do not address the underlying problem of overstocking occurring in the RPPs.

Alternative 1: No Action

This alternative is considered the environmental baseline (the no action alternative). Under this option, no silvicultural treatments are implemented and nature is allowed to run its course. The stands will remain fairly stagnant and overcrowded and significant mortality will continue. The stands will also remain highly susceptible to insect and disease outbreaks. Individual tree DBH and crown growth will remain suppressed with growth probably ranging from poor on the smaller-crowned trees to moderate on the larger-crowned trees.

Alternative 2: Clearcut all the stands and replant.

This is a very drastic approach and would likely receive negative feedback from the public. Visitation rates in the area may decline. It is very likely that ferns would take over and would interfere with the planted seedlings. Application of herbicide may be necessary to control the fern until the planted seedlings have become established.

Alternative 3: Select 35 to 40 seed trees per acre and harvest the rest of the trees in the stands.

The seed trees should have the largest crowns; show no signs of insects, disease, or decline; and should be spaced apart fairly equally. Due to the shallow rooting characteristics of red pine, it is very likely that windthrow will be a major problem. Fern is also likely to be a major problem in the establishment of naturally occurring seedlings. It is very likely that the sites will need to be planted at a later date due to these two potential problems. Cut, chip, burn, bury, or remove beetle-infested (fading) trees and debris (branches, tops, etc.).

Alternative 4: Implement a row thinning by removing every third row, which would remove one-third of the trees per acre and one-third of the basal area.

This type of thinning is easy to implement; felling and removal of the trees (larger DBH, larger crown, high vigor) is also fairly easy. This type of thinning would remove both desirable and undesirable trees (small DBH, small crown, and low vigor) and will provide growing space for both desirable and undesirable trees. It is likely that the smaller trees that have been suppressed over the last several years will continue to die even after the thinning. Accelerated crown and DBH growth is likely on most of the trees in the stand. Fern is likely to inhabit the area in the cut rows. Some windthrow may also occur. Cut, chip, burn, bury, or remove beetle-infested (fading) trees and debris (branches, tops, etc.).

Alternative 5: Implement a selective thinning by removing one out of every three trees in every row. (Recommended Action)

This would remove one-third of all trees and approximately one-quarter of the basal area. In each row, one tree would be removed from the first three trees, one from the next three trees, and so on, all the way to the end of the row. The trees to be harvested would be the least desirable of the three (smallest DBH, smallest crown, insect or disease infested). This type of thinning would accelerate crown and DBH growth on the most desirable trees in the stands by removing the least desirable trees. All the trees to be harvested would need to be marked. Felling and removal of the trees would be more difficult than in the row thinning. A conventional skidder would be too large to be used in this thinning operation. This type of thinning would increase individual tree vigor and the overall vigor of the stands. Windthrow would likely not be a significant problem. Cut, chip, burn, bury, or remove beetle-infested (fading) trees and debris (branches, tops, etc.).

RECOMMENDATIONS

Both Alternative 4 (row thinning) and Alternative 5 (selection thinning) would increase the overall vigor of the stands. Alternative 5 (selection thinning) would accelerate growth on the more desirable trees in the stands but would be harder to implement than row thinning because a conventional skidder is too large to operate in the stands, making removal of the harvested trees difficult. Alternative 4 (row thinning) would be easier to implement since there would be enough room in the stands to operate a skidder. Row thinning, however, would remove some desirable trees while leaving some undesirable trees. It is also likely that more mortality will occur after row thinning than after a selection thinning. Selection thinning will primarily concentrate on removing small-crowned, undesirable trees.

It is recommended that the Allegheny National Forest decide in favor of **Alternative 5**, which would likely provide the best results for individual tree health and overall health of the RPPs. The following practices are recommended during logging or thinning operations: 1) use as much of each tree as possible and avoid leaving debris in or near the stand, 2) remove harvested trees and infested (fading) trees from the stand as soon as possible, and 3) minimize the damage to remaining trees and roots by equipment and felling (Connor and Wilkinson 1983).

ADDITIONAL INFORMATION

Hemlock Woolly Adelgid

Adelgids are small, soft-bodied insects that feed on plant sap. The family is divided into two genera: *Adelges* and *Pineus*. The members of this family feed exclusively on conifers. There are six species of *Adelges* that occur in North America, of which only one is native (Montgomery 1999)—the Cooley spruce gall adelgid (*Adelges cooleyi*). This adelgid occurs coast to coast in Northern North America. Its primary hosts are recorded as white (*Picea glauca*), blue (*Picea pungens*), Sitka (*Picea sitchensis*), and Engelmann (*Picea engelmannii*) spruce (Baker 1972). It has an alternate host, Douglas fir (*Pseudotsuga menziesii*). There are 10 species of *Pineus* that occur in North America, of which seven are native. Four of these (the pine bark adelgid (*Pineus strobi*), the pine leaf adelgid (*Pineus pinifoliae*), the red spruce adelgid (*Pineus floccus*), and the spruce gall adelgid (*Pineus similes*)) seem to be indigenous to Eastern North America (Drooz 1989, Montgomery 1999). These species attack eastern white pine (*Pinus strobus*), red spruce (*Picea rubens*), and black spruce (*Picea mariana*) but seldom cause extensive damage (Drooz 1989, Montgomery 1999). Little is known about the population dynamics, ecological role, or the predator and parasite complex associated with these native adelgids.

Native to Japan, the hemlock woolly adelgid (*Adelges tsugae*) (HWA) is a pest of eastern hemlock (*Tsuga canadensis*) and Carolina hemlock (*T. caroliana*) (Onken et al. 1999), both of which are considered highly susceptible to the adelgid, with no documented resistance (Bentz et al. 2002). The latter tree species is found only in the southern region of the Appalachian Mountains (Onken et al. 1999). The HWA is currently established in 15 Eastern States from Georgia to Maine, and tree decline and mortality have increased at an accelerated rate since the late 1980s. For example, in the Shenandoah National Park, hemlock crown health has declined since the early 1990s. In 1990, greater than 77 percent of the hemlocks sampled were in a "healthy" condition; by 1999, less than 10 percent were in a "healthy" condition (Akerson and Hunt 1998). New Jersey has estimated a loss of 9 percent of its hemlock resource and 44 percent remains moderately to severely impacted by HWA (Onken et al. 1999). Similar adelgid-caused impacts are also affecting most districts of the Monongahela National Forest.

The hemlock woolly adelgid is parthenogenetic (an all-female population with asexual reproduction) and has six stages of development (the egg, four nymphal instars, and the adult) and two generations a year on hemlock[2]. Each adult adelgid can produce between 50 to 300 eggs in its lifetime (McClure 1989, 1995). Although natural mortality in HWA populations is commonly between 30 and 60 percent (McClure 1989, 1996), the reproduction potential of this insect remains high. This natural mortality is generally attributed to two likely causes: 1) an extended period of

[2] The hemlock woolly adelgid also has a winged form that is produced by the overwintering generation. This form must complete part of its life cycle on spruce. The apparent lack of a suitable spruce host for this form in Eastern North America results in a substantial loss of adelgids each year (McClure 1992b).

cold temperatures that coincides with a susceptible period of development for the adelgid, and/or 2) a sufficient loss in the nutritional quality and quantity of the food source, which is associated with the decline in health and vigor of the host tree (McClure 1996, Onken et al. 1999). Adelgid feeding can kill a mature tree in about 5 to 7 years (McClure et al. 2001). This tiny insect (~ 1 mm) feeds on all life stages of hemlock, from seedling to mature, old-growth tree. Dispersal and movement of HWA is associated with wind, birds, deer, and other forest-dwelling mammals. Humans also move the adelgid during logging and recreational activities (McClure 1995). Natural enemies capable of maintaining low-level HWA populations are nonexistent in Eastern North America (Van Driesche et al. 1996, Wallace and Hain 1998).

HWA was first reported in the Western U.S. in the 1920s (Annand 1924, McClure 2001). HWA populations on western tree species, including western hemlock (*Tsuga heterophylla*) and mountain hemlock (*T. mertensiana*), appear to be innocuous; these tree species are believed to be resistant because little damage has been reported (McClure 2001). Unfortunately, both tree species are of limited value for hybridization and planting due to their poor adaptation to the east coast environment (Bentz et al. 2002). In the East, HWA was first reported in the 1950s near Richmond, Virginia. It was considered to be more of an urban landscape pest and was controlled using a variety of insecticides applied with ground spraying equipment. Observations of the adelgid were periodically reported in several Mid-Atlantic States in the 1960s and 1970s but it was not until the 1980s that HWA populations began to surge and spread northward to New England at an alarming rate. By the late 1980s to early 1990s, infestations of HWA were reported to be causing extensive hemlock decline and tree mortality in hemlock forests throughout the East (McClure 2001).

Imidacloprid

Imidacloprid is a relatively new insecticide in the family of chemicals called neonicotinoids (Felsot 2001) in the chloronicotinyl subgroup (USDA Animal and Plant Health Inspection Service 2002). It has a mode of action similar to that of the botanical product nicotine, functioning as a fast-acting insect neurotoxicant (Schroeder and Flattum 1984) that binds to the nicotinergic receptor sites in the postsynaptic membrane of the insect nerve (USDA Animal and Plant Health Inspection Service 2002), mimicking the action of acetylcholine, and thereby heightening, then blocking, the firing of the postsynaptic receptors with increasing doses (Schroeder and Flattum 1984, Felsot 2001). Because imidacloprid is slowly degraded in the insect, it causes substantial disorder within the nervous system, leading in most cases to death (Mullins 1993, Smith and Krischik 1999).

Imidacloprid is considered to have low to moderate mammalian toxicity[3] (Mullins 1993). Chronic (repeated dose) toxicity studies have demonstrated that imidacloprid is neither carcinogenic nor mutagenic and demonstrates no primary reproductive toxicity (Mullins 1993). In studies of metabolic fate in rats, imidacloprid was rapidly absorbed and eliminated in the excreta (90 percent of the dose within 24 hours) with little bioaccumulation (0.5 percent of the dose after 48 hours) and no biologically significant differences occurring between sexes, dose level, and route of administration (USDA Animal and Plant Health Inspection Service 2002). Imidacloprid

[3] Largely because it does not bind nerve receptors in mammals sufficiently to trigger nervous activity (Felsot 2001). The selective toxicity of imidacloprid is perhaps best illustrated by its use in flea treatments approved for cats and dogs. Advantage® is applied directly to the animal's skin; this preparation carries very little, if any, risk to the animal or to the people, including children, who may handle the animal (USDA Animal and Plant Health Inspection Service 2002).

is an insecticide exhibiting both systemic and contact activity. The spectrum of activity primarily includes sucking insects (aphids, whiteflies, leaf and plant hoppers, thrips, plant bugs, and scales); many Coleopteran species; and selected species of Diptera and Lepidoptera. Activity has also been demonstrated for ants (Hymenoptera); termites (Isoptera); and cockroaches, grasshoppers, and crickets (Orthoptera). No activity has been demonstrated against nematodes or spider mites (Mullins 1993). In spider mites, imidacloprid has been demonstrated to cause an egg-laying enhancement (James and Price 2002). Since spider mites can be a problem in hemlock, any imidacloprid-treated tree should be carefully monitored for increases in mite populations.

Hazard Trees

The Morgantown Field Office (MFO) has included copies of Albers et al. (1996) and Pokorny (2003). Pokorny (2003) is also available in CD format (copy enclosed). The MFO is available to provide an NA hazard tree awareness session to ANF staff so that they might consider incorporating those aspects of the NA policy that might be applicable to the ANF. Additionally, copies of the 1996 USDA Forest Service Southeastern Area publication "Trees Need Their Skin Too" are included. It is suggested that this publication could be displayed in the glass-fronted information boards in the Recreational Area. It was observed that many members of the public had carved their names into the bark of beech trees and in so doing breached the tree's first line of defense.

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